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(71) Applicant *(for all designated States except US)*: BP OIL INTERNATIONAL LIMITED [GB/GB]; Britannic House, 1 Finsbury Circus, London EC2M 7BA (GB).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: CLARK, Alisdair, Quentin [GB/GB]; 18 Britten Close, Ash, Aldershot, Hants GU12 6LS (GB).

(74) Agent: WILSON, Michael, John; BP International Limited, Group Patents & Agreements, Chertsey Road, Sunbury on Thames, Middlesex TW16 7LN (GB).

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(54) Title: FUEL COMPOSITION

(57) Abstract

Unleaded aviation fuel compositions having a ~~Motor Octane Number of at least 98~~, for use in piston driven aircraft comprising triptane and at least one other saturated liquid aliphatic hydrocarbon having from 5 to 10 carbon atoms. The compositions preferably contain triptane, iso–pentane and either one or any combination of iso–octane, toluene and methyl tertiary butyl ether.

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FUEL COMPOSITION

The present invention relates to fuel compositions and in particular aviation gasolines possessing a high octane number suitable for use in piston-driven aircraft.

If a gasoline engine is run on a fuel which has an octane number lower than the minimum requirement for the engine, knocking will occur. Straight run gasoline has a low motor octane number but may be boosted to the required motor octane number of 82-88 for automotive use by the addition of octane boosters such as tetraethyl lead either alone or with refinery components such as reformate, alkylate, cracked spirit or chemical streams such as toluene, xylene, methyl tertiary butyl ether or ethanol. Aircraft piston-driven engines operate under extreme conditions to deliver the desired power e.g. high compression ratios. Due to the severity of the conditions e.g. with turbo charging or super charging the engine, aviation piston-driven engines require fuel of a minimum octane level higher than that for automotive internal combustion gasoline engines, in particular at least 98-100. The base fuel of an aviation gasoline has a motor octane number of 90-93. To boost the motor octane number sufficiently to the required level, tetraethyl lead is added to the aviation base fuel. The fuel may contain the organolead and also other octane boosters, such as those described above. Industrial and Engineering Chemistry Vol. 36 No. 12 p1079-1084 dated 1944 describes the use of triptane (2,2,3-trimethylbutane) in combination with tetraethyl lead in aviation gasoline. However, the presence of tetraethyl lead is the key to achieving high octane quality in aviation gasolines.

In modern day formulations tetraethyl lead is always used to boost the octane quality of the aviation gasoline to the desired level. However due to environmental concerns of the effect of lead and its compounds attempts are being made to find an alternative to the use of tetraethyl lead in aviation gasoline.

Conventional octane boosters such as ethers, aromatics, such as toluene, and non-lead metal compounds can boost the motor octane number of unleaded motor gasoline sufficiently high enough to achieve the desired value but they do not boost the motor octane number of an unleaded aviation gasoline sufficiently high enough to ensure satisfactory performance or suffer from other significant technical limitations.

US 5470358 describes the use of aromatic amines to boost the motor octane number of unleaded aviation gasoline to at least 98 but many aromatic amines are known to be toxic. They have high boiling points, no supercharge properties and high freezing points; they are also prone to produce gums.

There remains a need for an unleaded aviation gasoline of sufficiently high octane number suitable for use in piston driven aircraft

According to the present invention there is provided an unleaded aviation fuel composition, having a Motor Octane Number of at least 98, and usually a final Boiling Point of less than 170°C, and preferably a Reid Vapour Pressure at 37.8°C of between 38-60 kPascals,

which comprises:

component (a) at least one hydrocarbon having the following formula I

7 or 8 carbons

$$R\text{-}CH_2\text{-}CH(CH_3)\text{-}C(CH_3)_2\text{-}CH_3 \qquad I$$

wherein R is hydrogen or methyl

and component (b) at least one saturated liquid aliphatic hydrocarbon having 4 to 10 in particular 5 or 6 carbon atoms optionally with at least one other saturated liquid aliphatic hydrocarbon having from 5 to 10 carbon atoms

wherein at least 30% by volume of the total composition is a hydrocarbon of formula I.

2,2,3-trimethylbutane

If R is hydrogen the hydrocarbon is triptane. If R is methyl the hydrocarbon is 2,2,3 trimethylpentane. Especially preferred is triptane. Triptane and 2,2,3 trimethylpentane may be used individually or in combination with each other, for example, in a weight ratio of 10:90 - 90:10, preferably, 30:70 - 70:30.

The composition may comprise apart from a component (I), the hydrocarbon of formula I, a component (II) which is at least one of the known octane boosters described above especially an oxygenate octane booster, usually an ether, usually of Motor Octane Number of at least 96-105 e.g. 98-103. The ether octane booster is usually a dialkyl ether, in particular an asymmetric one, preferably wherein each alkyl has 1-6 carbons, in particular one alkyl being a branched chain

alkyl of 3-6 carbons in particular a tertiary alkyl especially of 4-6 carbons such as tert-butyl or tert-amyl, and with the other alkyl being of 1-6 e.g. 1-3 carbons, especially linear, such as methyl or ethyl. Examples of component (II) include methyl tertiary butyl ether, ethyl tertiary butyl ether and methyl tertiary amyl ether. The oxygenate may also be an alcohol of 1-6 carbons e.g. ethanol.

At least one component (I) may be present together with at least one component (II) in a combination. The combination may be, for example, triptane together with methyl tertiary butyl ether. The combination may be in a volume ratio of 40:60 to 99:1 e.g. 50:50 to 90 : 10, preferably 60:40 to 85:15. The volume percentage of ether may be up to 30% of the total composition e.g. 1-30%, such as 1-15% or 5-25%.

The motor octane number of the aviation gasoline of the invention is at least 98, for example 98-103, preferably 99 to 102. Motor Octane Numbers are determined according to ASTM D 2700-92. The hydrocarbons of formula I may also, especially when present in amount of at least 30% by volume, be used to provide gasolines of the invention with a Performance Number (according to ASTM D909) of at least 130 e.g. 130-170.

Triptane or 2,2,3 trimethylpentane may be used in a purity of at least 95% but is preferably used as part of a hydrocarbon mixture obtained, via distillation of a cracked residue, which is an atmospheric or vacuum residue from crude oil distillation, to give a C_4 fraction containing olefin and hydrocarbon, alkylation to produce a C_{4-9} especially a C_{6-9} fraction which is distilled to give a predominantly C_8 fraction, which usually contains trimethyl pentanes including 223 trimethyl pentane and/or 233 trimethyl pentane. To produce triptane this fraction can be demethylated to give a crude product comprising at least 5% of triptane, which can be distilled to increase the triptane content in the mixture; such a distillate may comprise at least 10% or 20% of triptane and 2,2,3 trimethylpentane but especially at least 50% e.g. 50-90% the rest being predominantly of other aliphatic C7 and C8 hydrocarbons e.g. in amount 10-50% by volume. Alternatively triptane and 2,2,3 trimethylpentane may be used in any commercially available form.

The invention will be further described with triptane exemplifying the compound of formula I but 2,2,3 trimethylpentane may be used instead or as well.

The amount of the hydrocarbon of Formula I alone or with component II may be present in the composition in an effective amount to boost the Motor Octane Number to at least 98 and may be in a percentage of from 35-92%,

preferably 60-90%, especially 70-90% by volume, based on the total volume of the composition. In particular the compound of formula I is usually in the composition in a percentage of 5-90%, 10-80%, 20-60% more especially 30-50% by volume, based on the total composition, though amounts of the compound of formula I of 10-45% are also very valuable; preferred are 20-90% or 40-90% or 50-90% by volume.

The composition also comprises a component (b). Component (b) is at least one saturated aliphatic liquid hydrocarbon of 4 to 10 preferably 5 to 8 in particular 5 or 6 carbon atoms, alone or with at least one saturated aliphatic liquid hydrocarbon (different from component(a)) having from 4 to 10 carbons in particular 5 to 10 carbon atoms, preferably 5 to 8 carbon atoms, especially in combination with one of 4 carbons. Component (b) may comprise a component (III) which is more volatile and has a lower boiling point than component (a) in particular one boiling at least 30°C such as 30-60°C below that of triptane at atmospheric pressure, and especially is itself of Motor Octane Number greater than 88 in particular at least 90 e.g. 88-93 or 90-92. Examples of component (III) include alkanes of 5 carbons in particular iso-pentane, which may be substantially pure or a crude hydrocarbon fraction from alkylate or isomerate containing at least 30% e.g. 30-80% such as 50-70%, the main contaminant being up to 40% mono methyl pentanes and up to 50% dimethyl butanes. Component (III) of boiling point 30-60°C less than that of triptane may be used as sole component (III) but may be mixed with an alkane of boiling point 60-100°C less than that of triptane e.g. n and/or iso butane in blends of 99.5:0.5 to 70:30, e.g. 88:12 to 75:25. Iso-pentane alone or mixed with n-butane is preferred, especially in the above proportions, and in particular with a volume amount of butane in the composition of up to 3.5% e.g. 1-3.5% or 2-3.5%.

Component (b) may also comprise a component (IV) having a boiling point higher than component (a) preferably one boiling at least 20°C more than the compound of formula I e.g. triptane such as 20-60°C more than triptane but less than 170°C and usually is of Motor Octane Number of at least 92 e.g. 92-100; such components (IV) are usually alkanes of 7-10 carbons especially 7 or 8 carbons, and in particular have at least one branch in their alkyl chain, in particular 1-3 branches, and preferably on an internal carbon atom and especially contain at least one -$C(CH_3)_2$- group. An example of component (IV) is iso-octane.

Component (b) may be a combination of at least one component (III)

together with at least one component (IV). The combination may be, for example, butane or isopentane together with iso-octane, and the combination may be in a volume ratio of 10 : 90 to 90 : 10, preferably 10:50 to 50:90, especially 15:85 to 35:65, in particular with butane or especially isopentane together with iso-octane. Especially preferred is the combination of isopentane together with iso-octane, in particular, in the above proportions, and optionally butane.

In another preferred embodiment, triptane and isopentane and optionally n-butane are present in the composition of the invention with 80-90% triptane and in particular in relative volume ratios of 80-90:10-15:0-3.5.

In a preferred embodiment of this invention component (a) is 2,2,3 trimethylbutane and component (b) is isopentane in combination with iso-octane, preferably in relative volume ratios of 10-80 : 5-25 : 10-80 in particular 30-50 : 5-25 : 35-60 or 15-45 : 10-18 : 45-75 or 60-80 : 10-18 : 10-25. Especially the composition contains 30-80% of triptane and the isopentane and iso-octane are in a volume ratio of 35-15 : 65-85.

In a further preferred embodiment of this invention the composition comprises component (a) as 2,2,3 trimethylbutane, methyl tertiary butyl ether and component (b) as isopentane in combination with n-butane, preferably in relative volume ratios of 50-90 : 5-30 : 10-15 : 0.1-3.5 in particular 50-80 : 10-25 : 10-15 : 0.1-3.5.

If desired the composition may comprise an aromatic liquid hydrocarbon of 6-9 e.g. 6-8 or 7-9 carbons, such as xylene or a trimethyl benzene, preferably but toluene, in particular in amounts of up to 30% by volume of the total composition e.g. 1-30% or 5-15%. In this case a preferred embodiment is a composition that may thus contain 50-95% e.g. 50-80% triptane, 5-25% e.g. 10-25% component (b) e.g. isopentane and 5-30%, for example toluene. The benzene content of the composition is preferably less than 0.1% by volume.

In another preferred embodiment the composition may comprise both the aromatic hydrocarbon and the ether. In this case a preferred composition may comprise 45-80% triptane 5-30% ether (with a preferred total of both of 70-85%), 10-25% component (b) (III) e.g. iso-pentane (optionally containing butane) and 5-20% toluene, all by volume.

The compositions may also comprise 10-90% e.g. 25-85%, 35-80%, or 35-90% by volume of triptane, 5-75% e.g. 8-55% by volume of a mixture predominantly of iso C_7 and iso C_8 hydrocarbons, but usually with small amounts

of iso C_6 and iso C_9 hydrocarbons and 5-40% e.g. 8-40% or 5-35% or 8-25% by volume isopentane. The triptane and mixture may be obtained as a distillation fraction obtained by the processing of crude oil and subsequent reactions as described above.

The unleaded aviation gasoline composition of the invention usually has a calorific value (also called Specific Energy) of at least 42MJ/kg (18075 BTU/lb) e.g. at least 43.5MJ/kg (18720 BTU/lb) such as 42-46 or 43.5-45MJ/kg. The gasoline usually has a boiling range (ASTM D86) of 25-170°C and is usually such that at 75°C 10-40% by volume is evaporated, at 105°C a minimum of 50% is evaporated, at 135°C a minimum of 90% is evaporated; the final boiling point is usually not more than 170°C preferably 80-130°C. The gasoline usually has a maximum freezing point of -60°C in particular -40°C. The Reid Vapour Pressure of the gasoline at 37.8°C measured according to ASTM D323 is usually 30-60kPa preferably 38-60 e.g. 38-55 or especially 38-49 or 45-55kPa.

The composition of the invention may contain at least one aviation gasoline additive, for example as listed in ASTM D-910 or DEF-STAN 91-90; examples of additives are anti-oxidants, corrosion inhibitors, anti-icing additives e.g. glycol ethers or alcohols and anti-static additives, especially antioxidants such as one or more hindered phenols; in particular the additives may be present in the composition in amounts of 0.1-100ppm e.g. 1-20ppm, usually of an antioxidant especially one or more hindered phenols. A coloured dye may also be present to differentiate the aviation gasoline from other grades of fuel.

The compositions of the invention are unleaded and have reduced toxicity, and are suitable for use in aviation gasoline for piston engine aircraft. Aromatic amines e.g. m-toluidine are usually substantially absent.

The invention will be illustrated by way of the following Examples

Example 1

An unleaded aviation gasoline was made by mixing 2,2,3 trimethylbutane of 99% purity with iso-pentane and iso-octane to give a composition consisting of 2,2,3 trimethylbutane 40%, isopentane 12%, and iso-octane 48% expressed in volume percentages of the total gasoline.

The motor octane number (MON) of the gasoline was 99.9 as determined by ASTM D2700-92 and the Reid Vapour Pressure was 33kPa.

Example 2

An unleaded aviation gasoline contained the gasoline of Ex.1 with 8mg/l of

a mixture of 75% 2,6-ditertiary, butyl phenol and 25% tertiary and tri tertiary, butyl phenols, as antioxidant.

Example 3

An unleaded aviation gasoline was made from a crude triptane fraction. A cracked residue from the distillation of crude oil was distilled to give a C_4 fraction containing olefin and saturates. The fraction was alkylated (i.e. self reacted) to form a crude C_8 saturate which was distilled to give a fraction boiling 95-120°C, which contained 223 and 233 trimethyl pentane. This fraction was demethylated by reduction to give a first fraction containing about 17% triptane and 83% iso C_6-C_9 with a majority of iso C_7 and iso C_8 hydrocarbons. This first fraction was redistilled to produce a second fraction of 87% triptane and 13% iso C_7 and C_8.

90 parts by volume of this second fraction was mixed with 10 parts of isopentane to give an unleaded aviation gasoline of MON value 99.1. Addition of 8mg/l of the phenol mixture of Ex.2 gave an oxidation stabilized unleaded aviation gasoline fuel.

Example 4

The process of Example 3 was repeated with the first fraction containing the 17% triptane redistilled to give a third fraction containing 37% triptane and 63% iso C_7 and C_8. 82 parts by volume of this third fraction were mixed with 18 parts of isopentane to give an unleaded aviation gasoline of MON value 98.0. Addition of the phenol mixture as in Ex.3 gave an oxidation stabilised aviation gasoline fuel.

Examples 5-9

In these Examples 2,2,3 trimethylbutane (triptane) 99% purity was mixed with iso-pentane and butane, and optionally toluene and/or methyl tertiary butyl ether, to produce a series of gasoline blends, for making unleaded aviation gasolines.

The formulated gasolines were made by mixing each blend with a phenolic antioxidant 55% minimum 2,4 dimethyl-6-tertiary butyl phenol 15% minimum 4 methyl-2, 6-ditertiary-butyl phenol with the remainder as a mixture of monomethyl and dimethyl-tertiary butyl phenols (DEF STAN 91-90 RDE/A/610).

In each case the gasolines were tested for Motor Octane Number, and their Reid Vapour Pressure at 37.8°C and their calorific value, and their distillation properties and freezing point. In addition for Example 10 the Indicated Mean Effective Pressure (IMEP) was determined (according to ASTM D909) to give the Supercharge Performance Number. The results are shown in table 1.

Table 1

Example	5	6	7	8	9
Composition % v/v					
Triptane	85.0	73.0	53.0	87.8	87.0
Isopentane	12.0	14.0	14.0	12.0	11.8
Butane	3.0	3.0	3.0	0.2	1.2
Toluene	-	10.0	10.0	-	-
MTBE	-	-	20.0	-	-
Antioxidant mg/l	15	15	24	17	15
Distillation °C					
Initial Boiling Point	43.0	41.0	36.5	47.5	46.5
T10%	63.5	63.5	57.0	68.0	67.0
T40%	77.0	79.0	69.9	76.5	77.0
T50%	78.5	81.5	73.8	78.5	79.0
T90%	80.5	87.5	88.4	80.5	81.0
Final Boiling Point	115.0	116.0	107 7	80.5	90.0
Reid Vapour Pressure kPa	51.3	52.5	58.3	40.4	46.3
MON	99.8	98.3	98.0	99.7	99.8
Freezing point °C	-54	<-80	<-80	-49	-51.5
Supercharge (IMEP)	-	-	-	-	>160
Specific energy MJ/kg	44.5	44.1	42.1	44.5	44.5

T 10% means the temperature at which 10% by volume of the composition has distilled.

Claims:

1. An unleaded aviation fuel composition, having a Motor Octane Number of at least 98, and having a final boiling point of less than 170°C which comprises:
component (a) comprising at least one hydrocarbon having the following formula I

$$R\text{-}CH_2\text{-}CH(CH_3)\text{-}C(CH_3)_2\text{-}CH_3 \qquad (I)$$

wherein R is hydrogen or methyl
and component
(b) at least one saturated liquid aliphatic hydrocarbon having 5 or 6 carbon atoms
wherein at least 30% by volume of the total composition is a hydrocarbon of formula I.

2. A composition according to Claim 1 wherein the hydrocarbon of formula I is triptane.

3. A composition according to Claim 1 or 2 having a Reid Vapour Pressure at 37.8°C of 38 - 60 kPascals.

4. A composition according to Claim 3 with a Reid Vapour Pressure of 38-49 kPascals.

5. A composition according to anyone of the preceding Claims wherein component (b) comprises a component (III) which is more volatile and has a lower boiling point than triptane.

6. A composition according to Claim 5 wherein component (III) has a Motor Octane Number greater than 88.

7. A composition according to either of Claims 5 or 6 wherein component (III) comprises iso-pentane.

8. A composition according to Claim 7 wherein the fuel composition comprises 5-40% by volume of iso-pentane.

9. A blend according to claim 8 which comprises 5-25% by volume of iso-pentane.

10. A composition according to any one of Claims 7-9 wherein component (III) comprises butane and iso-pentane.

11. A composition according to anyone of the preceding Claims wherein the fuel composition comprises 0.1-3.0 % by volume of n-butane.

12. A composition according to any one of the Claims 5-11 wherein component (b) comprises in addition to component (III) a component (IV) having a boiling point higher than triptane but less than 170°C.

13. A composition according to Claim 12 wherein component (IV) has a Motor Octane Number of at least 92.

14. A composition according to either of the preceding Claims 12 or 13 wherein component (IV) is iso-octane.

15. A composition according to anyone of the preceding Claims wherein the composition comprises up to 30% by volume of an aromatic liquid hydrocarbon of 6-8 carbons.

16. A composition according to Claim 15 wherein the composition comprises 5-30% by volume of toluene.

17. A composition according to any one of the preceding claims which comprises as component (I) said hydrocarbon having the formula I and a component (II) an oxygenate octane booster.

18. A composition according to Claim 17 wherein the component (II) is an ether.

19. A composition according to Claim 18 wherein the ether is methyl tertiary butyl ether.

20. A composition according to anyone of the preceding Claims wherein 35-92% by volume of the total composition is the combined volume of the hydrocarbon of formula I and methyl tertiary butyl ether (if present).

21. A composition according to any one of Claims 1-14 which comprises 80-90% of triptane, with isopentane and optionally butane.

22. A composition according to any one of Claims 1-14 which comprises 30-80% of triptane, and also III isopentane and IV iso-octane, the volume ratio of III to IV being 35-15 : 65-85.

23. A composition according to Claim 16 which comprises 50-90% triptane, 5-25% isopentane and 5-30% toluene.

24. A composition according to Claim 23 which comprises 0-15% methyl tertiary butyl ether.

25. A composition according to anyone of the preceding Claims which has a calorific value of at least 42MJ/kg.

26. A composition according to Claim 25 which has a calorific value of at least 43.5MJ/kg.

27. A composition according to anyone of the preceding Claims wherein the Performance Number for supercharging is at least 130.

28. An unleaded aviation fuel having a Motor Octane Number of at least 98, and having a final boiling point of less than 170°C which comprises:
component (a) comprising at least one hydrocarbon having the following formula I

$$R\text{-}CH_2\text{-}CH(CH_3)\text{-}C(CH_3)_2\text{-}CH_3 \qquad (I)$$

wherein R is hydrogen or methyl
and component
(b) at least one saturated liquid aliphatic hydrocarbon having 5 or 6 carbon atoms wherein at least 20% by volume of the total composition is a hydrocarbon of formula I, together with at least one aviation gasoline additive selected from anti-oxidants, corrosion inhibitors, anti-icing additives and anti-static additives.

29. A fuel according to Claim 28 wherein the antioxidant is one or more hindered phenols.

30. Use of the hydrocarbon of formula I as an octane booster in an unleaded aviation gasoline to give a composition or fuel as claimed in any of the preceding claims.

31. The use of an unleaded aviation fuel according to Claim 28 or 29 in an aircraft piston driven engine.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 97/03084

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 C10L1/06 C10L1/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 C10L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DATABASE WPI Section Ch, Week 9622 Derwent Publications Ltd., London, GB; Class H06, AN 96-220407 XP002054753 & RU 2 044 032 C (INTERAVIAGAZ STOCK CO) see abstract	1,5, 7-10,14, 30
A	GB 2 106 933 A (ALDON AUTOMOTIVE LIMITED) 20 April 1983 see claims 1,2,4,7	1,2,15, 16
A	US 4 633 028 A (OWEN HARTLEY ET AL) 30 December 1986 see claims 1,8 see column 6, line 58 - column 7, line 25	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Information on patent family members

Ir. ational Application No
PCT/GB 97/03084

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 2106933 A	20-04-83	NONE	
US 4633028 A	30-12-86	AU 628283 B	17-09-92
		AU 6200586 A	26-03-87
		CA 1269403 A	22-05-90
		EP 0216604 A	01-04-87

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 97/03084

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 C10L1/06 C10L1/02

According to International Patent Classification(IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 C10L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DATABASE WPI Section Ch, Week 9622 Derwent Publications Ltd., London, GB; Class H06, AN 96-220407 XP002054753 & RU 2 044 032 C (INTERAVIAGAZ STOCK CO) see abstract	1,5, 7-10,14, 30
A	GB 2 106 933 A (ALDON AUTOMOTIVE LIMITED) 20 April 1983 see claims 1,2,4,7	1,2,15, 16
A	US 4 633 028 A (OWEN HARTLEY ET AL) 30 December 1986 see claims 1,8 see column 6, line 58 - column 7, line 25	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 February 1998	25/02/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	De Herdt, O

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		AU 6200586 A	26-03-87
		CA 1269403 A	22-05-90
		EP 0216604 A	01-04-87

```
=> s toluene
        122739 TOLUENE
          1415 TOLUENES
L4      123358 TOLUENE
                 (TOLUENE OR TOLUENES)

=> s iso-octane or isooctane or trimethylpentane
        157500 ISO
            17 ISOS
        157516 ISO
                 (ISO OR ISOS)
         34389 OCTANE
          1611 OCTANES
         35295 OCTANE
                 (OCTANE OR OCTANES)
           709 ISO-OCTANE
                 (ISO(W)OCTANE)
          9199 ISOOCTANE
            72 ISOOCTANES
          9249 ISOOCTANE
                 (ISOOCTANE OR ISOOCTANES)
          3152 TRIMETHYLPENTANE
           132 TRIMETHYLPENTANES
          3229 TRIMETHYLPENTANE
                 (TRIMETHYLPENTANE OR TRIMETHYLPENTANES)
L5       12626 ISO-OCTANE OR ISOOCTANE OR TRIMETHYLPENTANE

=> s l3 and l4 and l5
L6           7 L3 AND L4 AND L5

=> d l6 1-7 all

L6   ANSWER 1 OF 7  CAPLUS  COPYRIGHT 2002 ACS
AN   1998:352915  CAPLUS
DN   129:56326
TI   Unleaded aviation fuel composition
IN   Clark, Alisdair Quentin
PA   BP Oil International Ltd., UK; Clark, Alisdair Quentin
SO   PCT Int. Appl., 15 pp.
     CODEN: PIXXD2
DT   Patent
LA   English
IC   ICM  C10L001-06
     ICS  C10L001-02
CC   51-7 (Fossil Fuels, Derivatives, and Related Products)
FAN.CNT 1
     PATENT NO.        KIND  DATE          APPLICATION NO.  DATE
     ---------------   ----  --------      ---------------  --------
PI   WO 9822556         A1   19980528      WO 1997-GB3084   19971111
         W:  AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE,
             DK, EE, ES, FI, GB, GE, GH, HU, ID, IS, JP, KE, KG, KP, KR, KZ,
             LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL,
             PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US,
             UZ, VN, YU, ZW, AM, AZ, BY, KG, KZ, MD, RU, TJ, TM
         RW: GH, KE, LS, MW, SD, SZ, UG, ZW, AT, BE, CH, DE, DK, ES, FI, FR,
             GB, GR, IE, IT, LU, MC, NL, PT, SE, BF, BJ, CF, CG, CI, CM, GA,
             GN, ML, MR, NE, SN, TD, TG
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